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Assessing intensity of mistletoe infestation in Teak Clonal Seed Orchard (CSO) Padangan, East Java

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Abstract

Teak Clonal Seed Orchards (CSO) in Perum Perhutani are an essential source of improved seeds that are managed with appropriate silvicultural practices including pest and disease monitoring. However, the attack of mistletoe has been observed recently in the orchard and become a significant parasite causing decrease fruit yields in many mother trees. Attempts to overcome of this problem have not yet been well formulated due to lack of basic information on the mistletoe. The main objective of this research was to assess the degree of teak mistletoe infestation within the teak CSO, located in Padangan near Cepu, East Java. The assessment was carried out in compartments of teak clones that have been designated as observation sample plots/OSPs (n = 4) with size of more than 1 ha depending on distribution observation measurement plots/OMPs within OSP following various infestation intensities, namely low, moderate, high and control (no infestation). Four OMPs (@ 50 m x 50 m) per OSP, each comprising of 25 trees, were made to record infestation intensity referring to modified TMR (true mistletoe rating) of 9-class systems, i.e. rating of mistletoe amount and infected branch intensity. Results showed that levels of mistletoe infestation ranging from rather slight to rather moderate (TMR 0.86 – 3.58). Additional data from map of teak mistletoe species distribution showed that *Dendrophthoe pentandra* and *Macrosolen tetragonus* were observed in the whole area, while *Viscum articulatum* was found only in certain area.

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Keywords: teak; mistletoe; TMR (True Mistletoe Rating); clonal seed orchard; Perhutani.

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1. Introduction

Mistletoes are macro parasite plants that are hemiparasitic on plants and source of drugs compounds [1]. The role and benefit of mistletoe as hemiparasite are also advantageous in addition to harming, among others, as key species in the ecosystems, especially forests involved in the food chain together with mistletoe birds that dispersed seed, so that mistletoe occupy a particular niche in the ecological niches [2]. Hemiparasite disorders are commonly found in teak stands [3]. The impact on physiological processes and economic losses of teak due to mistletoe attacks includes a decrease in tree vigour and growth increments, less fruit and seed, drying of branches, logs quality including strength properties of wood and tree mortality [4].

Up to now, mistletoe disorder in teak plantation forests of particular KPHs/FMUs (Kesatuan Pemangkuan Hutan/Forest Management Unit) and Clonal Seed Orchards (CSOs) belonging to Perum Perhutani (a state owned forest enterprise), Java, Indonesia, has been claimed in a general condition of non-outbreak status. Although, the preliminary data on mistletoe infestation showed the intensity of the attacks in some KPHs and seed production areas (SPAs) already ranged from 10.7 - 49.6% [5]. In particular, additional results from an inventory carried out in CSO Padangan (650.3 ha) showed that the number of trees infected in various levels of attacks were already 17338 individuals indicating almost $\frac{1}{3}$ (one third) of the total number of existing trees ($n=59944$ individuals). These level were considered as a significant attack [5]. To date, availability of baseline information on biological characters of mistletoe as hemiparasite especially in teak are still limited. Therefore, in-depth and comprehensive basic research is indispensable to provide sufficient scientific data for appropriate parasite control program. In collaboration with Research and Development Center of Perum Perhutani in Cepu, a particular study was carried out with main objective to assess the intensity of mistletoe infestation in teak clones of CSO Padangan, East Java.

2. Methods

This study was conducted during May 2014-2015 in the compartments and blocks of Clonal Seed Orchard (CSO) Padangan geographically located between $111^{\circ} 34'11.88''$ – $111^{\circ} 36'11.11''$ E and $07^{\circ} 11'43.53''$ – $07^{\circ} 13'35.09''$ S with an altitude of 90 meters above sea level. The area has been divided into 8 compartments and 132 blocks (± 5 ha for each block). The teak clones were planted at a spacing of 10 m x 10 m with a total number of 59944 individual trees. Planting stock materials, i.e. clones and ramets, were produced from grafting/budding process using buds (scion) collected from selected plus trees in Perum Perhutani plantations. There were 144 clones planted repeatedly in blocks and year by year since 1983 until 1996 according to the working plan of the CSO [6]. The average annual rainfall during 2006-2014 was 2262.9 mm with 51-171 rainy days. Average range of air temperature from May 2014 to May 2015 were 22-30 °C in the morning (07.00 to 8.00 am), 28-47 °C in the noon time (12.00 to 13.00 pm), and 22-44 °C in the afternoon (16.00 to 17.00 pm). The relative humidity was around 69% - 97% in the morning, 34.9% - 88.4% in the daylight, and 38% - 89.5% in the afternoon [7].

2.1. Preliminary research

Preliminary assessment for the intensity of the mistletoe attacks was conducted by referring to the map of mistletoe infestation with a scale 1: 18000. In CSO Padangan the groupings of compartments and block stands were classified based on the number of teak trees as hosts attacked by the parasite, namely: I (> 100 trees infected), II (50-100 trees infected), and III (<50 trees infected), in combination with field checking by counting the number of trees attacked in temporary Observation Measuring Plot (OMP) with the size 50 m x 50 m. As the results of the initial survey showed that the number of trees affected in the field were diverse in the early determination of OMP in OSP units, so intensity of the initial attack was predicted in the OMP by counting the number of parasites found in the individual trees with the following criteria: light $(1-8) \pm 2$ trees, moderate $(9-16) \pm 2$ trees, and heavy $(17-25) \pm 2$ trees. The distribution of sample points in the Observation Sample Plot (OSP) and OMP is presented in Fig. 1.

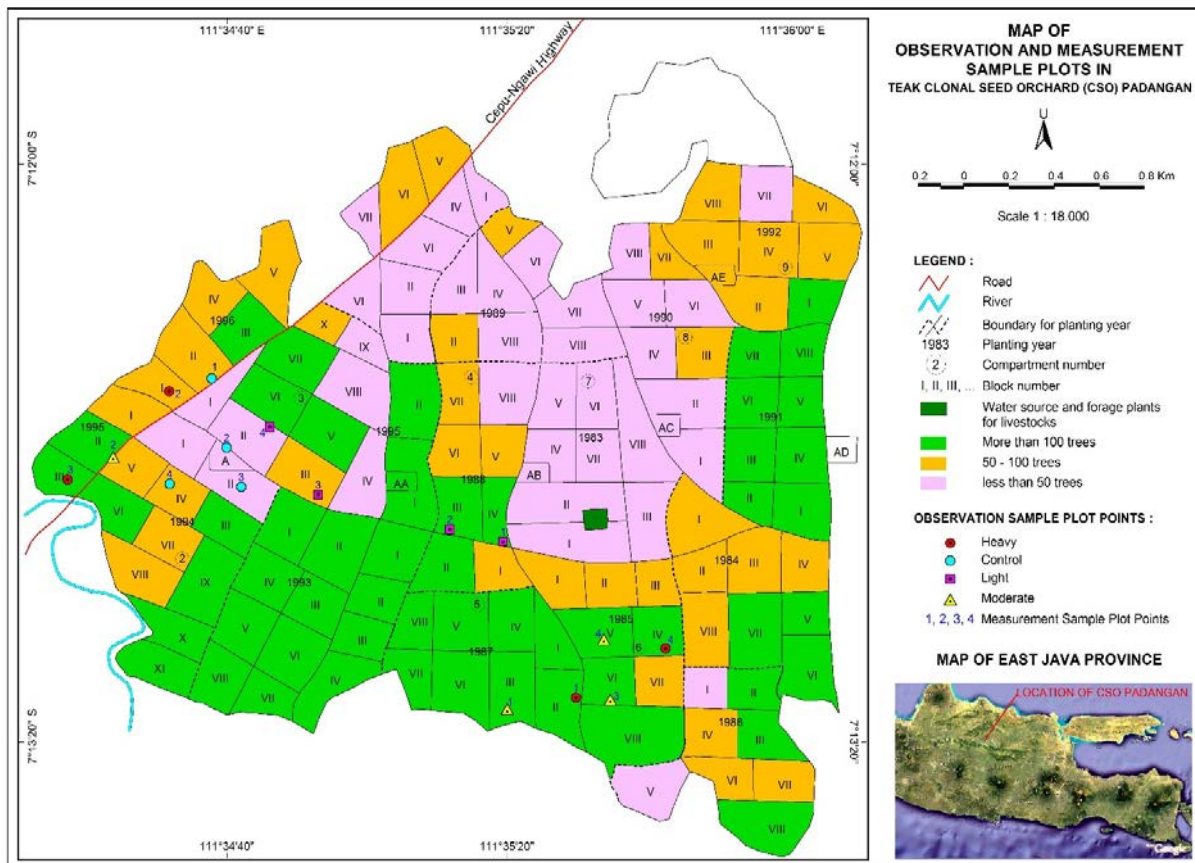


Fig. 1. Map of OSP and OMP location in CSO Padangan

2.2. Research implementation

In this study, four units of OMP were randomly placed inside OSP units with the following infestation intensity: light, moderate, heavy, and no infestation as control. If OSP and OMP could not be obtained in the area as ideally laid out in Fig. 2, they could be laid out beyond the ideal condition as long as meeting the criteria of infestation intensity (light, moderate, heavy and no infestation). In each OSP unit, OMPs were made in the form of square mini-plots (50 m x 50 m), representing a stand condition being attacked by the mistletoe. Selection of OMPs were done by referring to the list of OMPs following the criteria specified in the CSO Padangan and was chosen randomly as replicates in OSP units (Fig. 2). After making a list of sub-OMP units containing teak trees attacked by parasites, five sub-OMP units (10 m x 10 m for each sub unit) were randomly selected in each OMP unit (Fig. 3).

2.3. Intensity criteria of parasite infestation

The intensity criteria of parasite infestation was determined using the modified TMR (true mistletoe rating) system, which was adapted to the nature or character type of parasite in a tree in a tropical region (Fig. 4). The modification was performed in this study due to unavailability of suitable formula, which involves the application method assessment of the intensity of the parasite, especially in forest stands in Indonesia. Before, this method application was based on a review of mistletoe assessment techniques with DMR (dwarf mistletoe rating) of six-classes [11], [12], [13], [14], according to Hawkesworth (1977) in [15] in which its 6-class system is commonly used for infestation of

dwarf mistletoes in the USA; DMR seven-class [16]; DMR four-class [18]. Also the application of TMR (true mistletoe rating) three-class and TMR five-class [17].

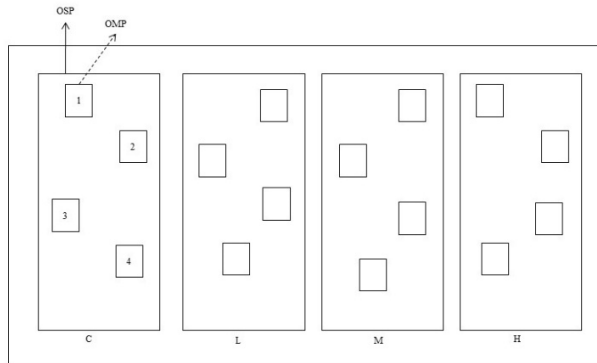


Fig. 2. Design of ideal position of OSPs and OMPs in OSP unit in CSO Padangan, modified from CRC990/EFForTS Plots [8] (C = control, L = light, M = medium, H = heavy. Minimum distance between OMP with the other one is 200 m [9], [10]

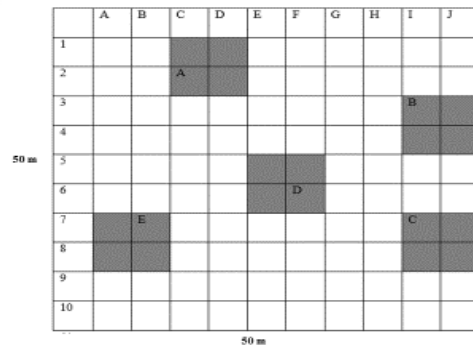


Fig. 3. An example of random position of su OMP unit, modified from CRC990/EFForTS Plots [8]

In the modified TMR system, crown of teak tree was divided into three parts i.e. top, middle and bottom. This is based on assumptions and interpretations that the model of teak tree canopy width was divided into two parts, i.e light crown section and shaded crown section [19]. The light crown section was further divided into two sub-sections.

In this TMR-scale system, two scale (rating and sub-rating) of the three parts of the canopy were summed. So that the mistletoe infected trees will have TMR scores varied from 1 to 9 indicating that this study applied nine class rating system. Trees with a score TMR 0 were considered as no infection, TMR 0.1 - 3 were light infection, TMR 3.1 - 5 were moderate infection, TMR 5.1 - 7 were heavy infection and TMR 7.1 - 9 were very heavy infection. TMR stand value was an average score of trees attacked by the parasite in the OMPs. Thus, the Figures 2, 3 and 4 describes that OSP was considered to represent a scale habitat (CSO Padangan), OMP represents the scale of the host (teak) and tree top quadrants represent microhabitat scale (part of crown), refer to [18]. The complete details of the calculation of TMR-scale are shown in Table 1.

2.4. Parameter measurement

Parameter measurement was estimated by using three patterns of parasite infestation (top, middle, bottom) presented in Fig. 4 calculating the number of mistletoe that infest the branches, sub-branches, twigs, small branches and possibly grow on stems. The damage level of branches, twigs or stems were observed by calculating the number of branches, twigs or stems which have dieback as the effects of mistletoe attack in the area of the canopy of each individual tree in OMP. The tree dimensional parameter measurement includes total height, bole height, tree diameter, and crown diameter that were done using census method in the OMP.

2.5. Data analysis

The analysis of R-Studio v 0.98 [20] is carried out using an index morisita (IMOR) and index morosita standardization test (IMST) to check whether the attack of the parasite are spread uniformly (IMOR < 1, IMST < 0), randomly (IMOR = 1, IMST = 0), or in groups (IMOR > 1, IMST > 0). Moreover, chi-square test was performed to

assess the hypotheses of spread pattern, namely in groups (H_0) and random scatter pattern (H_1). Criteria of H_0 will be accepted if the value of chi-square $p < X^2$ table, at $\alpha = 5\%$.

Table 1. The detail of TMR-scale system at teak stand used in this study, modified from DMR and TMR [11, 12, 13, 14, 16, 17, 18]

TMR rating and (sub rating); TMR scale of tree	Scale Rating TMR @ part of any 1/3 portion of crown	Infestation criteria	
		Qualitative	Semi quantitative
0	0 + 0 + 0	class 0, no infestation	
1(0.5, 1); TMR 0.1 – 2.0	0 + 1 + 0; 0 + 0 + 1; 1 + 0 + 0; different sub rating (1, 2)	Rather light	Class I Light infection (TMR of stand) = 0.1 – 3.0
2(0.5, 1); TMR 2.1 – 3.0	0 + 0 + 2; 0 + 1 + 1; 0 + 2 + 0; 1 + 0 + 1; 1 + 1 + 0; 2 + 0 + 0; different sub rating (1, 2) as scale rating TMR 1 – 3, add sub-sub rating (a, b, c) As scale rating TMR 1 – 3, add sub-sub rating: N = swelling minor stem ($\leq 25\%$ part of stem infected), M ($> 25\%$ stem infected)	Light Rather light - light (a, b, c)	Light infection (a, b, c) Light infection (N, M) ^a
3(0.5, 1); TMR 3.1 – 4.0	..., 0 + 0 + 3; 0 + 1 + 2; 0 + 2 + 1; 0 + 3 + 0; 3 + 0 + 0; 1 + 0 + 2; 1 + 1 + 0; 1 + 1 + 1; 1 + 2 + 0; 2 + 0 + 1; 2 + 1 + 0; different sub rating (1, 2) ..., 0 + 1 + 3; 0 + 2 + 2; 0 + 3 + 1; 1 + 0 + 3; 1 + 1 + 2; 1 + 2 + 1; 1 + 3 + 0; 2 + 0 + 2; 2 + 1 + 1; 2 + 2 + 0; 3 + 0 + 1; 4 + 0 + 0; 0 + 4 + 0; 0 + 0 + 4; different sub rating (1, 23)	Rather moderate Moderate	Class II Moderate infection (TMR of stand) = 3.1 – 5.0
4(0.5, 1); TMR 4.1 – 5.0	As scale rating TMR 3 – 5, add sub-sub rating (a, b, c) As scale rating TMR 3 – 5, add sub-sub rating: N = swelling minor stem ($\leq 25\%$ part of stem infected), M ($> 25\%$ stem infected) ..., 0 + 2 + 3; 0 + 3 + 2; 1 + 1 + 3; 1 + 2 + 2; 1 + 3 + 1; 2 + 0 + 3; 2 + 1 + 2; 2 + 2 + 1; 3 + 0 + 2; 3 + 1 + 1; 3 + 2 + 0; 4 + 1 + 0; 4 + 0 + 1; 0 + 5 + 0; 0 + 0 + 5; ...; different sub rating (1, 2) ..., 0 + 3 + 3; 1 + 2 + 3; 1 + 3 + 2; 2 + 1 + 3; 2 + 2 + 2; 3 + 0 + 3; 3 + 1 + 2; 3 + 2 + 1; 4 + 2 + 0; 4 + 0 + 2; 4 + 1 + 1; 0 + 6 + 0; 0 + 0 + 6; ...; different sub rating (1, 2, 3)	Rather moderate – moderate (a, b, c)	Moderate infection (a, b, c) Moderate infection (N, M)
5(0.5, 1) TMR 5.1 – 6.0	..., 0 + 3 + 3; 1 + 2 + 3; 1 + 3 + 2; 2 + 1 + 3; 2 + 2 + 2; 3 + 0 + 3; 3 + 1 + 2; 3 + 2 + 1; 4 + 2 + 0; 4 + 0 + 2; 4 + 1 + 1; 0 + 6 + 0; 0 + 0 + 6; ...; different sub rating (1, 2, 3)	Rather heavy	Class III Heavy Infection (TMR of stand) = 5.1 – 7.0
6(0.5, 1); TMR 6.1 – 7.0	..., 1 + 3 + 3; 2 + 2 + 3; 3 + 1 + 3; 3 + 3 + 1; 4 + 3 + 0; 4 + 0 + 3; 4 + 1 + 2; 4 + 2 + 1; 0 + 7 + 0; 0 + 0 + 7; ...; different sub rating (1, 2)	Heavy	Class IV Very heavy infection (TMR of stand) = 7.1 – 9.0
7(0.5, 1); TMR 7.1 – 8.0. [8(0.5, 1); 9(0.5, 1); 10(0.5, 1), ...] TMR 8.1 – 9.0	as scale rating TMR 5 – 9, add sub-sub rating (a, b, c) As scale rating TMR 5 – 9, add sub-sub rating: N = swelling minor stem ($\leq 25\%$ part of stem infected), M ($> 25\%$ stem infected)	Very heavy Rather heavy – heavy – very heavy (a, b, c)	Heavy infection, very heavy (a, b, c) Heavy infection, very heavy (N, M)

^a Rating 0, if part of any 1/3 portion of the crown, no appear infection; Rating 1, if part of any 1/3 portion of the crown, number of mistletoe 4, if part of any 1/3 third portion of the crown, number of mistletoe 4; Rating 5, if part of any 1/3 third portion of the crown, number of mistletoe 5; Rating 6, if part of any 1/3 third portion of the crown, number of mistletoe 6; Rating 7, if part of any 1/3 third portion of the crown, number of mistletoe 7; Rating 8, if part of any 1/3 third portion of the crown, number of mistletoe 8; Rating 9, if part of any 1/3 third portion of the crown, number of mistletoe > 8 . Sub Rating (0.5), total of crown area, ratio of amount of branch of mistletoe to of branch (at stem of free branching) $\leq 50\%$; Sub Rating (1.0), if branch infestation $> 50\%$. Sub-sub Rating (a), minimal 1 small twig or 1 big twig is dieback (db); Sub-sub Rating (b), minimal 1 big branch or 1 small branch dieback (db); Sub-sub Rating (c), minimal 1 stem dieback (db). Resultante Rating = rating (Σ mistletoe) + sub rating (1 branch parasitized); sub-sub rating (db). Example of tree sample with amount of rating = 0 + 0 + 0 = 0 (class 0/no infection) or Rating 1 + 1 + 1 = 3, sub rating branch infestation intensity (1.0), sub-sub rating (a), so total class rating I (3 + 1)(a) = TMR 4 (a) or light infection (db twig).

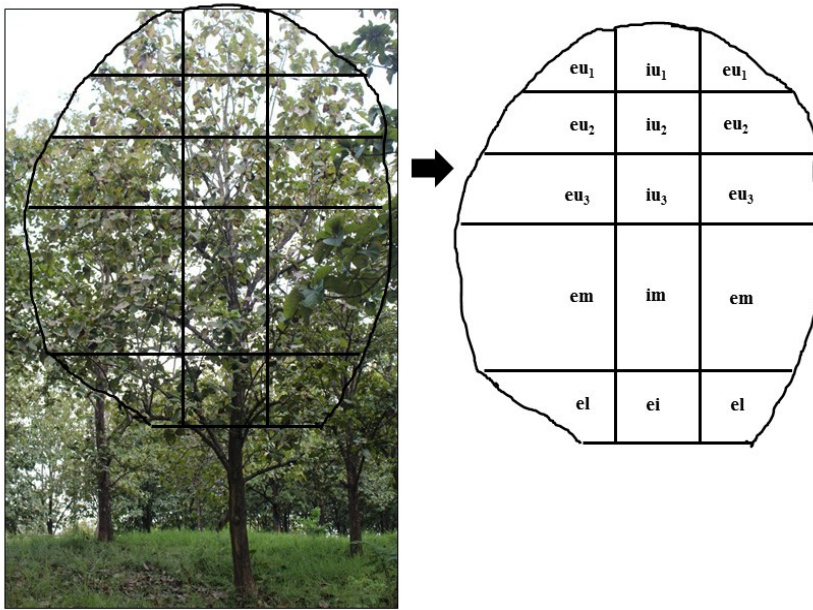


Fig. 4. An observed mistletoe at teak crown fraction/tree top quadrants [18], which modified the 6 quadrants to be 10 quadrants); eu = external upper (sub upper 1,2,3), iu = internal upper (sub upper 1,2,3), em = external medium, im = internal medium, el = external lower, il = internal lower.

3. Results and discussion

3.1. Intensity of attacks

The results of measurements of the intensity of parasite attack and TMR on teak clones in CSO Padangan are presented in Table 2 and Fig. 5. The intensity of infestation value in light of PCP ranges from 0.32 to 0.43 with the acquisition of TMR values ranging from 0.86 to 1.21 [light (rather light)] and the value of TMI range of 2.20 to 2.90; moderate PCP range of 0.50 to 0.65 with the acquisition of TMR values ranging from 1.29 to 3.27 [light - moderate (rather moderate)] with TMI values ranging from 2.58 to 5.00; heavy PCP range of 0.74 to 0.83 with the acquisition of TMR values ranging from 1.80 - 3.58 [light - moderate (rather moderate)] with TMI values ranging from 2.44 to 4.48. Overall the TMR obtained ranged from 0.86 – 3.58 indicating that there was no mistletoe infestation with heavy level of TMR (TMR 5-7) (Table 2).

This study used the nine class-system of True mistletoe rating (TMR)(scale 0-9) on five level infestation (control, light, moderate, heavy and very heavy). The criteria for determining grade rating (scale 0-9) in this study was based on the rating number of parasites per host tree combined with the intensity of parasite-infected branches that are counted in the overall area of the crown but not in every section of it. This is due to the shape of teak branches that tend to form an angle $< 90^{\circ}$ against the main shaft of the stem or the branch growth that tend to not be flat, instead to be rather vertical. Determination of the class rating was based on the intensity of parasite-infected branches on each section of the crown [12] and the calculation of other external symptoms of the mistletoe infection such as swelling and branch dieback, swelling of the trunk and asymmetric crown [21].

Monitoring and evaluation on the intensification of parasite attacks using scale changes DMR or TMR over time is an important programs that should be implemented after the measurement of the attack intensity. Geils and Mathiasen [22] reported an intensification of dwarf mistletoe attacks in the Southwestern Douglas-fir on each third of the crown DMR classes had increased 0, 1, 2, or more within 10 years. The model assumed a faster rate of intensification (two classes DMR per decade) for heavily infected stands on a small diameter, and the lowest intensification (half class DMR per decade) for a mild infection stands on a large diameter.

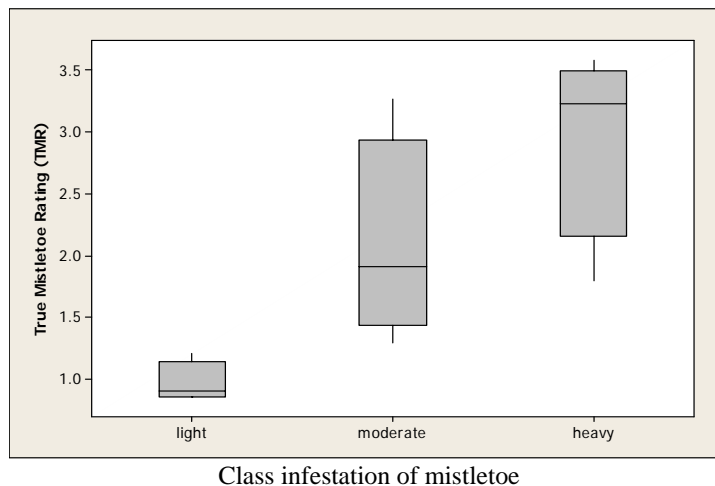


Fig. 5. TMR value of class of infestation mistletoe in teak CSO Padangan

- PCP classification based on the intensity of the number of trees parasitized, and TMR

The calculation of cross-tabulation between OSP (the intensity of the number of trees parasitized) with OSP (TMR) revealed that 100 % of the light OSP (the intensity of the number of trees parasitized) was corresponding in degree with the light category in TMR (100%), while 100% of moderate OSP (the intensity of the number of trees parasitized) was commensurate with light (75%) and moderate (25%) categories in TMR. Then, 100% of heavy OSP (the intensity of trees attacked by mistletoe) was equal to the light TMR category (25%), moderate TMR (75%) and heavy TMR (0%). The magnitude of the classification accuracy between OSP (the intensity of the number of parasitized trees) with OSP (TMR) is 58.33% or > 50%.

The classification relation between the intensity of the number of trees parasitized and TMR value using Chi-square test and Linear-by-linear association showed that a likelihood ratio of p-value was $0.043 < \alpha$ (0.05) and $0.031 < \alpha$ (0.05), respectively. This result suggests a significant correlation between the intensity of the number of trees parasitized and TMR value. The value of the Spearman correlation was 0.65 with a p-value of $0.022 < \alpha$ (0.05) indicating a positive and significant correlation. Thus, increasing of the OSP criteria based on the number of trees parasitized at a light, moderate, heavy level will increase the value of TMR.
- Superiority of TMR value assessment

In the past, assessing mistletoe infestation intensity at teak stand was done by counting a number of mistletoe that appear in teak host [23-25]. Then, the ratio of the attacked tree and the total tree in sample unit were obtained [27]. Recently, TMR method has been developed to assess the intensity of parasite attacks on teaks in Indonesia in this study. This method has more superiority in comparison with the previous methods in which TMR method could asses mistletoe infestation intensity with two variables (in part of crown and branch intensity) more accurately, those could determine the location of dominant mistletoe in part of crown, and their associated parameters in more details (semi quantitative).

3.2. Parts of trees attacked by mistletoes

In the crown area, mistletoe attacks were found on branches, sub-branches, twigs, small branches and the upper part of the main trunk. There were no mistletoe attacks found outside the crown area or stems under the main bole height. In total, 536 parasites were found in the trees of teak clones in OSP and OMP. The dominant location in the crown area that is infested by mistletoes ($\geq 10\%$) were in a large part of the middle of big twigs, middle of small and very small twigs and in the tips of large branch. Subsequently the other twigs and branches, however, parasites were not found in the base of small branch.

Field observation showed that there is such a preference on how the mistletoe distributes in the tree in which the smaller circumference or diameter of part of tree in crown area, i.e. twigs, the more mistletoe presents. Early assumption considered that part of twig has thinner bark and mild than branch or even the stem bark in area crown. Those will help in early establishment of mistletoe seeds that are dispersed by birds as vector that can penetrate to cell and tissue of wood and later to be in *xylem tapping* forming haustorium. As part of branch and stem are relatively thicker, consequently they rather inhibit physically for early establishment or germination of mistletoe seed. First, this may be due to loss of reserve ions of nutrient in endosperms prior forming haustorium and second it cannot reach xylem-tapping to establish seedling. This assumption is in line with report of [28] that in Cibodas garden *Callistemon citrinus* (Myrtaceae) and *Ficus* (Moraceae) more preference by mistletoe *Scurrula oortiana* because have twig/branch bark thinner from others. Again [29] research about host specification and characteristic *Viscum articulatum* in Pulau Dua Mangrove Banten Indonesia explained that infestation of mistletoe tend to increase in twigs and small twigs that has smaller size including very small twigs (result of this study). This fact leads to a research question how to estimate the mistletoe seed deposition.

The parasitization of mistletoe teak influence mainly the occurrence of dieback branches /twigs. The level of dieback showed that the proportion of dieback on the part of large branches was 39.3%, small branches was 32.0%, large twigs was 33.2%, small twigs and very small was 26.3% and the part of the upper trunk was 62.5%. The highest frequency of dead branches/twigs and upper trunk by the parasitization was caused by *Dendrophthoe pentandra* (91%), followed by *Viscum articulatum* as hyperparasite on *D. pentandra* (6%) and *Macrosolen tetragonus* (3%).

3.3. Horizontal and vertical distribution of crown growing mistletoe

Of the total number of parasites in the trees ($n=536$), shows a vertical and horizontal distribution of the mistletoe found in the crown area ($\geq 10\%$) was part of upper crown sub-middle (inner side) (17.35%), the upper crown sub upper (inner side) (15.86%), the middle crown (outer side) (15.30%), the upper crown sub-middle (outer side) (14.37%), the middle crown (inner side) (11.38%). This means mistletoe spread in the upper crown (70.02%) more dominant than the middle (26.44%) and the lower (3.54%) of it and mistletoe that occupy part crown of inside (52.51%) more than outside of it (47.49%). This result indicate that preference bird as mistletoe vector occupy in the upper of crown of inside.

Based on the observation of mistletoe species, the record of the geographical coordinates of the point and the map of mistletoe distribution, it is known that *D. pentandra* and *M. tetragonus* were distributed in whole area, while *V. articulatum* was found only in certain area (Fig. 6).

3.4. Attack pattern

The infestation pattern of parasites was determined from the availability of data on the number of mistletoes in each sample tree. The result showed that the number of parasites per tree varied from 1 to 18 parasites, but there was not found the number of parasites as many as 10, 11, 14, 15, 17 per tree. Subsequently, the data of parasites distribution per tree in each OMP were analyzed using R-statistic test. The results showed that the index pattern morisita (IMOR) was higher than 1 and the index pattern of morisita standardization (IMST) was higher than 0, indicating all sample

trees were attacked by parasites spreading in groups. Chi-square result shows p-value < X2 table, suggesting that spread patterns was in groups. This result is in accordance with report of [23] describing that mistletoe spread in cluster (in groups) for plant age of young, moderate and old. This means that existing mistletoes can be potential sources for the spreading of new mistletoes that are found nearby. The patterns of mistletoe infestation in every OMP are illustrated in Fig. 7.

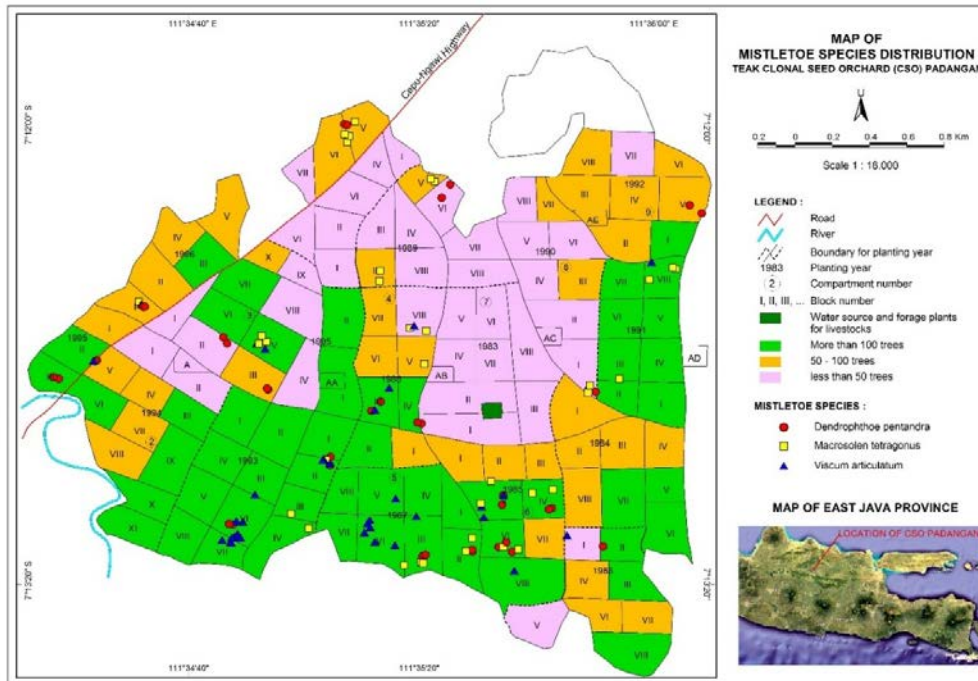


Fig. 6. Map of mistletoe species distribution in CSO Padangan.

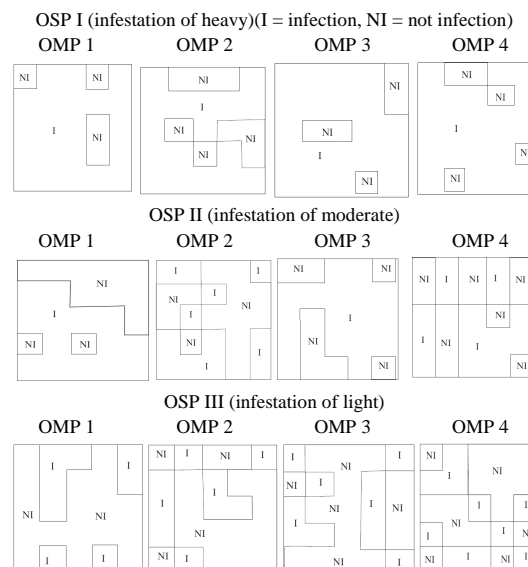


Fig. 7. Infestation of mistletoe patterns in every OMP in teak CSO Padangan.

Table 2. Assessing intensity of mistletoe infestation in teak CSO Padangan

								Value and criteria of intensity of infestation							
No	OSP	OMP	Compart/ Block	age (ye ar)	Diametre mean	Total height mean	Bole height mean	Intensity of infestation (IS)[24]			TMR Amount of	Mean	TMI Amount of	Mean	Criteria TMR;
								Amount of tree paratized	Total tree	IS					
1	Control	1	03/II	18	35.58 ± 7.61	17.32 ± 3.41	3.53 ± 1.34	0	0	0	0	0	0	0	C
		2	02/I	18	31.01 ± 8.31	13.82 ± 4.16	2.90 ± 1.24	0	0	0	0	0	0	0	C
		3	02/II	20	26.54 ± 7.09	11.88 ± 3.79	1.68 ± 0.72	0	0	0	0	0	0	0	C
		4	02/V	20	28.36 ± 13.62	14.84 ± 7.36	3.03 ± 1.34	0	0	0	0	0	0	0	C
2	Light	1	04/IV	26	25.86 ± 6.54	13.13 ± 3.15	2.03 ± 1.10	8	25	0.32	21.5	0.86	21.5	2.69	L [rather L](db stw, tw);
		2	04/III	26	35.58 ± 6.01	18.42 ± 2.14	3.71 ± 1.21	9	25	0.36	21.5	0.86	21.5	2.39	L [rather L](db stw, tw);
		3	03/III	19	33.07 ± 6.95	14.91 ± 2.13	1.79 ± 0.70	10	23	0.43	22	0.96	22	2.20	L [rather L](db stw, tw);
		4	03/II	19	36.76 ± 0.41	18.25 ± 4.08	2.35 ± 1.44	10	24	0.42	29	1.21	29	2.90	L [rather L](db stw, tw);
3	Moderate	1	05/III	27	37.72 ± 6.75	18.02 ± 2.85	5.37 ± 1.19	14	22	0.64	41.5	1.89	41.5	2.96	L [rather L](db stw, tw, br, st);
		2	02/II	19	37.12 ± 6.36	18.96 ± 3.18	5.33 ± 1.59	12	24	0.50	31	1.29	31	2.58	L [rather L](db stw, tw);
		3	06/VI	29	33.88 ± 11.82	17.99 ± 3.08	4.18 ± 1.49	17	26	0.65	85	3.27	86	5.00	M [rather M](db stw, tw, br);
		4	06/V	29	37.26 ± 3.23	19.39 ± 7.57	4.13 ± 4.02	14	25	0.56	48.5	1.94	48.5	3.46	L [rather L](db stw, tw, sbr, st);
4	Heavy	1	05/II	27	25.91 ± 8.95	12.42 ± 2.67	3.23 ± 1.05	23	29	0.79	94	3.24	94	4.09	M [rather M](db stw, tw, sbr, br, st);
		2	03/I	18	34.43 ± 10.26	17.53 ± 7.76	3.07 ± 1.59	17	23	0.74	41.5	1.80	41.5	2.44	L [rather L](db stw, tw, br)
		3	02/III	19	41.63 ± 6.62	19.15 ± 2.88	3.97 ± 1.46	20	25	0.80	89.5	3.58	89.5	4.48	M [rather M](db stw, tw);
		4	06/IV	29	38.39 ± 7.07	20.19 ± 4.39	4.75 ± 2.08	20	24	0.83	77.5	3.23	77.5	3.88	M [rather M] (db stw, tw, sbr);

^aIS = intensity of infestation (prevalence) = \sum tree paratized by mistletoe / \sum total tree; TMR = True mistletoe rating, TMR = \sum TMR / \sum total tree; TMI = True mistletoe intensity, TMI average = \sum TMR / \sum tree infected; Clasification infestation teak mistletoe (TMR): 0 (no infection), 0.1 – 3 (light), 3.1 – 5 (moderate), 5.1 – 7 (heavy), 7.1 – 9 (very heavy); C = control, L = light, M = moderate; db = dieback; stw = small twig, tw = twig, sbr = sub branch, br = branch, st = ste

4. Conclusion

Intensity of mistletoe infestation in CSO Padangan as estimated by TMR method revealed that the TMR scores of around 0.86 – 3.58 (rather light – rather moderate) and a heavy infestation was not found. Accuracy of assessing TMR classification compared with the amount of host parasitized were 58.33%. Infestation pattern spreads in groups or clusters. Thus, controlling the mistletoe infestation is suggested to be focused in area or groups in order to reduce the activity range of birds as mistletoe vector.

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